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ABDURAXMON ASIMOVICH ISHANXODJAYEV TAVALLUDINING 85 YILLIGIGA BAG‘ISHLANGAN “TRANSPORT INSHOOTLARI: ZAMONAVIY TEXNOLOGIYALAR, SEYSMIK BARQARORLIK” MAVZUSIDAGI XALQARO ILMIY-AMALIY KONFERENSIYASI ILMIY ISHLARI TO‘PLAMI

Toshkent davlat transport universiteti texnika fanlari doktori, professor, transport qurilishi sohasida taniqli olim, fan va texnika sohasidagi Abu Rayhon Beruniy nomli O‘zbekiston Davlat mukofoti laureati, “Shuxrat belgisi” ordeni, “Sharafli mehnati uchun” medali, “Oliy talim fidoiysi”, Oliy talim alochisi”, “SSSR ixtirochisi”, “Yo‘l ustalarning ustozi”, “Seysmik xavfsizlik sohasi alochisi” ko‘krak nishonlari sohibi **Abduraxmon Asimovich Ishanxodjayev tavalludining 85 yilligiga** bag‘ishlangan **“Transport inshootlari: zamonaviy texnologiyalar, seysmik barqarorlik”** mavzusidagi xalqaro ilmiy-amaliy konferensiya ilmiy ishlari to‘plami chop etildi.

Abduraxmon Asimovich 100 dan ortiq ilmiy asarlar, shu jumladan, 2 ta monografiya, 2 ta darslik, 18 ta chet elda chop etilgan ilmiy maqola va ishlab chiqarishga tadbiq etilgan 6 ta ixtiroga berilgan guvohnoma va patentlar muallifidir. Uning ilmiy maslahatchiligi va ilmiy rahbarligida 2 ta doktorlik, 8 ta nomzodlik va 4 ta texnika fanlari bo‘yicha falsafa doktori (PhD) ilmiy darajalariga dissertatsiyalar yoqlandi, ko‘p sonli ilmiy-tadqiqot mavzulari – fundamental va amaliy Ilmiy grantlar, yo‘l-ko‘prik qurilishi bo‘yicha Respublika va soha me’yoriy hujjatlari yaratganlar.

Ishanxodjayev Abduraxmon Asimovich 1962 yilda Toshkent temir yo‘l muhandislari institutini “Sanoat va fuqaro qurilishi” mutaxassisligi bo‘yicha tugatib, bir yil O‘zbekiston suv xo‘jaligi Davlat loyiha instituti muhandisi, to‘rt yil “Toshshaxarqurilish Bosh Boshqarmasi” qurilish tashkilotlarida qurilish ustasi va ish bajaruvchi lavozimlarida ishladi. Shu davrda u hozirgi Respublika Prezidenti devoni binosi qurilishida ishtirok etdi, Toshkent viloyati Bo‘stonliq rayoni “Chimyon” dam olish zonasida tiklanayotgan “Quyoshli” pioner lager qurilishiga rahbarlik qildi. Nihoyat, u 5-yillik loyiha va ishlab chiqarish tajribasiga ega mutaxassis sifatida 1967-yil dekabrida O‘zbekiston Fanlar Akademiyasi mexanika va inshootlar seysmik mustaxkamligi institutiga, ushbu institut direktori, o‘sha paytda fan nomzodi, keyinchalik akademik Tursunboy Rashidov ilmiy rahbarligida aspiranturaga kiradi va keyingi 20-yil davomida kichik va katta ilmiy hodim, laboratoriya mudiri lavozimlarida faoliyat ko‘rsatdi.

Shu davrda uning bevosita rahbarligi va ishtirokida O‘zbekiston Fanlar Akademiyasi mexanika va inshootlar seysmik mustahkamligi institutida dunyoda yagona “Metropolitenlar zilzilabardoshligi” laboratoriyasi tashkil etildi. Ushbu laboratoriya Toshkent metr opoliteni Chilonzor metro yo‘lini noqulay grunt sharoitlari va yuqori seysmik zonada loyihalash va qurishda, metro qurilishi tajribasida birinchi bo‘lib yirik yig‘ma temirbeton elementlardan tiklanadigan yurish va bekat tonnellarining yangi, zilzilabardosh konstruksiyalari yaratish va tadbiq etishda faol qatnashdi. Toshkent metrosi Chilonzor yo‘lining qurilgan bo‘laklarida ulkan eksperimental tadqiqotlar o‘tkazildi, metro tajribasida birinchi bo‘lib muhandis-seysmometrik kuzatuvlar tashkil qilindi. Laboratoriya ilmiy xodimlari va izlanuvchilaridan 10 dan ortiq kishi nomzodlik va doktorlik dissertatsiyalari yoqladilar. Kafedrada bajarilgan ilmiy-tadqiqotlar natijalarining ishlab chiqarishga tadbiqidan hosil bo‘lgan katta miqdordagi iqtisodiy samara institut va O‘zbekiston Fanlar Akademiyasi hisobotlarida qayd etildi.

Ustozimiz 30 yildan ortiq muddatda rahbarlik qilgan Toshkent avtomobil-yo‘llar instituti “Ko‘priklar va transport tonnellari” kafedrasi O‘zbekiston Respublikasi, shuningdek, Osiyo, Afrika va Lotin Amerikasi mamlakatlari uchun ko‘priksozlik bo‘yicha oliy malumotli kadrlar tayyorladilar. Shuni qayd etish lozimki, professor Ishanxodjaev Abduraxmon Asimovich turli yillarda Tojikiston va Qirg‘iziston Respublikalari hududlarida, Armaniston Respublikasining Spitak shahrida ro‘y bergan kuchli zilzilalar oqibatlarini o‘rganish va tahlil qilishda, sobiq Ittifoq Fanlar Akademiyasi prezidiumi qoshidagi seysmologiya va zilzilabardosh qurilish bo‘yicha idoralararo kengash azosi sifatida faol ishtirok etdi. Keyingi yillarda u Toshkent shahri va Respublikada qurilayotgan ulkan transport inshootlari konstruksiyalari, shu jumladan Toshkent metropoliteni yer usti xalqa yo‘li konstruksiyalarini ekspertiza qilish jarayonlarida ham bevosita ishtirok etdi.

Ishanxodjayev Abduraxmon Asimovich 50 yildan ortiq davrda ilmiy darajalar beruvchi ixtisoslashgan va ilmiy kengashlarning raisi, ilmiy kotibi, a’zosi va ushbu kengashlar qoshidagi ilmiy seminar raisi sifatida 300 dan ortiq mutaxassislarning doktorlik, nomzodlik va falsafa doktori ilmiy darajasini olish jarayonida qatnashdi. Hozirda u Toshkent Davlat Transport Universiteti huzuridagi doktorlik dissertatsiyalari himoyasi bo‘yicha ilmiy kengash a’zosi va ushbu ilmiy kengash qoshidagi ilmiy seminar raisi, O‘zbekiston mexaniklar jamiyatining kengashi a’zosi, Sharof Rashidov nomli Samarqand Davlat universiteti va O‘zbekiston Fanlar Akademiyasi seysmologiya instituti qoshidagi doktorlik dissertatsiyalari himoyasi bo‘yicha ilmiy kengashlar a’zosi sifatida ilmiy darajadagi mutaxassislar tayyorlashda faol ishtirok etmoqdalar.

Mazkur ilmiy-amaliy konferensiyaning maqsadi transport qurilishi sohasida olib borilayotgan zamonaviy ilmiy tadqiqotlar yo‘nalishlarini muhokama qilish, jumladan ko‘priklar va tunnellar qurilishi, metropolitenlar, yuqori seysmik hududlarda transport obyektlarining ishonchliligi va seysmik mustahkamligi, zamonaviy hisoblash va loyihalash usullari, hamda innovatsion muhandislik yechimlari bo‘yicha ilmiy natijalar almashuvini ta’minlashdan iboratdir.

Konferensiyada O‘zbekiston Respublikasi hamda xorijiy mamlakatlarning oliy o‘quv yurtlari va ilmiy-tadqiqot institutlari olimlari, shuningdek, muhim ilmiy tadqiqot natijalariga ega bo‘lgan ishlab chiqarish vakillari o‘z ilmiy ishlari bilan ishtirok etdilar.

“Transport inshootlari: zamonaviy texnologiyalar, seysmik barqarorlik” mavzusidagi xalqaro ilmiy-amaliy konferensiyaning asosiy yo‘nalishlari quyidagilardan iborat:

1. Transport inshootlari uchun zamonaviy konstruktiv yechimlar va materiallar;
2. Ko‘priklar hamda yo‘l o‘tkazgichlarni diagnostika qilish, ta’mirlash va mustahkamlash texnologiyalari;
3. Seysmik hududlarda transport inshootlarini loyihalash va ekspluatatsiya qilishdagi dolzarb masalalar;
4. Ilg‘or xorijiy tajriba, innovatsion yondashuvlar va amaliy tavsiyalar.

Ushbu ilmiy-ma’rifiy to‘plam Abduraxmon Asimovich Ishanxodjayevning tabarruk 85 yoshga to‘lishi munosabati bilan nashr etilib, unda transport qurilishi sohasida faoliyat yuritayotgan yetakchi olimlar, professor-o‘qituvchilar va malakali mutaxassislarning ilmiy izlanishlari jamlangan. To‘plamda transport qurilishining dolzarb muammolari, zamonaviy muhandislik yechimlari, ilmiy-nazariy va amaliy tadqiqot natijalari yoritilib, ushbu sohaning bugungi holati va istiqboldagi rivojlanish yo‘nalishlari aks ettirilgan. Mazkur nashr Abduraxmon Asimovichning transport qurilishi faniga qo‘shgan ulkan hissasiga nisbatan chuqur hurmat va e’tirof ramzi sifatida tayyorlangan.

Physicochemical analysis of expanded clay concrete modified with mineral and chemical additives

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Abstract: This article examines the physicochemical properties of expanded clay concrete compositions modified with mineral and chemical additives. In the research process, the influence of additives on the microstructure of cement stone, hydration processes, and the formation of the filler-bonding interface zone (CZ) was analyzed. The results of physicochemical analysis showed that mineral and chemical additives compress the cement matrix, reduce capillary porosity, and increase the structural stability of the interface zone. The obtained results have scientific and practical significance for the creation of energy-saving and high-performance expanded clay concrete materials.

Keywords: Expanded clay concrete, mineral additives, chemical additives, physicochemical analysis, cement stone, microstructure, filler-binder interface zone (CZ), hydration processes, capillary porosity

1. Introduction

Today, the sustainable development of the construction industry is closely linked to the creation of energy-efficient, resource-saving, and environmentally safe building materials. Reducing heat energy consumption during the operation of buildings, reducing carbon emissions, and ensuring the long-term stability of structures are one of the main tasks of modern building materials technology. In these conditions, lightweight concretes, especially concrete based on expanded clay aggregate, are of particular importance due to the combination of such properties as low density, sufficient mechanical strength, heat and fire resistance.

Despite the wide range of practical applications of expanded clay concrete, its formation on the basis of highly porous aggregate creates a number of technological and structural problems. In particular, the high water absorption of expanded clay aggregate granules, the relative porosity and weakness of the zone of the aggregate-bonding interface (contact-transition) formed between the cement stone and the aggregate, limit the operational indicators of concrete, such as strength, water resistance, and frost resistance. Therefore, the modification of the composition of expanded clay concrete, especially the control of its microstructure and interface zone, is an urgent scientific and technical task [1].

In recent years, the integrated use of mineral and chemical additives has been widely used as an effective approach to improving the properties of expanded clay concrete. Mineral additives activate secondary hydration processes in the cement matrix and serve to compact the microstructure, while chemical additives allow improving the rheological properties of the concrete mix, reducing the water-cement ratio, and controlling the hardening process. As a result of the combined action of these additives, an increase in the structural homogeneity of expanded clay concrete, a decrease in porosity in the contact zone, and an increase in bond strength are observed [2].

However, the analysis of existing scientific research shows that the mechanisms of physicochemical action of mineral and chemical additives introduced into expanded clay concrete, in particular, the processes of cement hydration, the formation of the phase composition, and changes occurring at the level of microstructure of the interface zone, have not been sufficiently systematically studied. In many works, the influence of additives is assessed mainly through physical and mechanical indicators and is not deeply related to structural and physicochemical analyses.

From this point of view, the identification and analysis of physicochemical changes occurring in the process of modifying the composition of expanded clay concrete is of great scientific importance. X-ray phase analysis, infrared spectroscopy, thermal analysis, and electron microscopic studies allow for in-depth study of the structure of cement stone, hydration products, and the formation of the filler-binder interface zone. Such an approach creates a solid theoretical basis for scientifically based regulation of the properties of expanded clay concrete and the development of optimal compositions[3].

In this article, the physicochemical properties of expanded clay concrete compositions modified with mineral and chemical additives are analyzed, and the influence of additives on the microstructure of cement stone, hydration processes, and the formation of the filler-binder interface zone is scientifically substantiated. The obtained results have scientific and practical significance for the creation of energy-saving, resource-saving, and high-performance expanded clay concrete materials [4].

2. Materials and methods

In order to determine the phase changes occurring in the composition of expanded clay concrete under the influence of mineral and chemical additives, the samples were investigated by X-ray phase analysis. This method allows for the identification of new compounds formed under the influence of crystalline phases, hydration products, and additives formed in the cement stone.

As a result of X-ray phase analysis, the presence of the main hydration products - calcium silicate hydrates (C-S-H), calcium hydroxide (Ca (OH) 2), ettringite, and other crystalline phases, as well as changes in their intensity, were

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assessed. Based on the obtained diffractograms, the influence of mineral and chemical additives on the activation of secondary hydration processes in the cement matrix, as well as on the content of free calcium hydroxide, was analyzed.

Fig. 1. X-Ray Difraktometr AL-27 MINI. iScope Microscopes used to study the microstructure of materials

The data of X-ray phase analysis served as an important scientific basis for assessing the formation of the microstructure of expanded clay concrete and the state of the filler-binder interface zone (CZ).

Scanning electron microscopy (SEM) was used to study the microstructure of expanded clay concrete, the features of the formation of the filler-binder interface (contact-transition) zone between cement stone and expanded clay granules. This method allows for high-precision analysis of the distribution of pores in concrete, the morphology of crystalline structures, and structural homogeneity.

Based on electron microscopic images, the microstructure of samples of modified expanded clay concrete without the addition of mineral and chemical additives was compared. In particular, under the influence of additives, a compaction of the cement stone structure, a decrease in the number of capillary pores, and an improvement in cohesion in the interface zone were revealed.

The results of SEM analysis made it possible to explain changes in the physical, mechanical, and operational properties of expanded clay concrete at the microstructural level and played an important role in the scientific substantiation of the effectiveness of mineral and chemical additives.

3. Experimental part

Quantitative and qualitative X-ray diffraction analysis of expanded clay concrete with the addition of the complex chemical additive Sika 43.36.

The results of X-ray phase analysis (XRD) showed that the phase composition of the expanded clay concrete sample has a complex and stable composite structure. In the diffractogram, crystalline phases characteristic of the mineral peroxynite, in particular forsterite (Mg_2SiO_4) and magnesite ($MgCO_3$), are revealed, the intensity of the peaks of which confirms the active participation of these mineral components in the composition of concrete. These phases have high thermal and chemical stability and are an important factor in improving the operational properties of concrete.

The presence of an amorphous background along with crystalline phases on the diffractogram indicates that the cement stone and hydrated products are in a partially amorphous state. The combined formation of crystalline and amorphous phases determines the composite nature of expanded clay concrete, ensuring its mechanical strength and resistance to environmental influences. In general, the results of X-ray phase analysis confirm the presence of phase harmony in the composition of expanded clay concrete with the addition of the mineral peroxynite, which indicates the possibility of reliable and stable operation of concrete under long-term operating conditions [5].

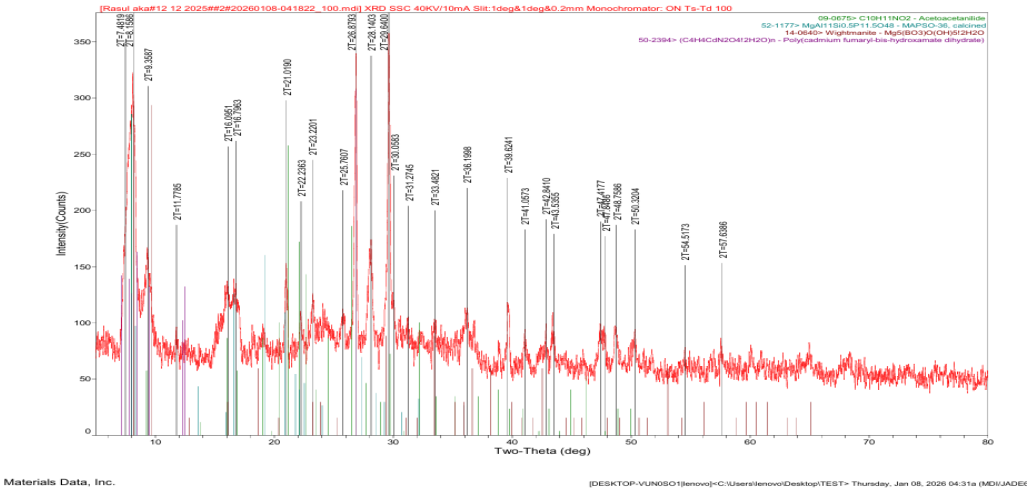


Fig. 3. X-ray phase analysis of a sample of expanded clay concrete without additives

The results of X-ray phase analysis show an increase in the proportion of calcium silicate hydrates (C-S-H) in the composition of cement hydration products as a result of the introduction of the mineral additive peroxynite into the composition of expanded clay concrete. If intensive peaks characteristic of the calcium hydroxide (Ca (OH) 2) phase are observed in the control sample, then a decrease in the intensity of these peaks is observed in the modified compositions. This is explained by the puzolamic activity of peroxynite and the microstructural compaction of the cement stone.

X-ray phase analysis of the expanded clay concrete sample was carried out in the range of 5-80° 2θ. A number of distinct and intense diffraction peaks are observed on the obtained diffractogram, which indicates the presence of phases with a crystalline structure in the sample. At the same time, the relatively wide and smooth nature of the background line confirms the partial amorphous state of the cement stone and hydration products.

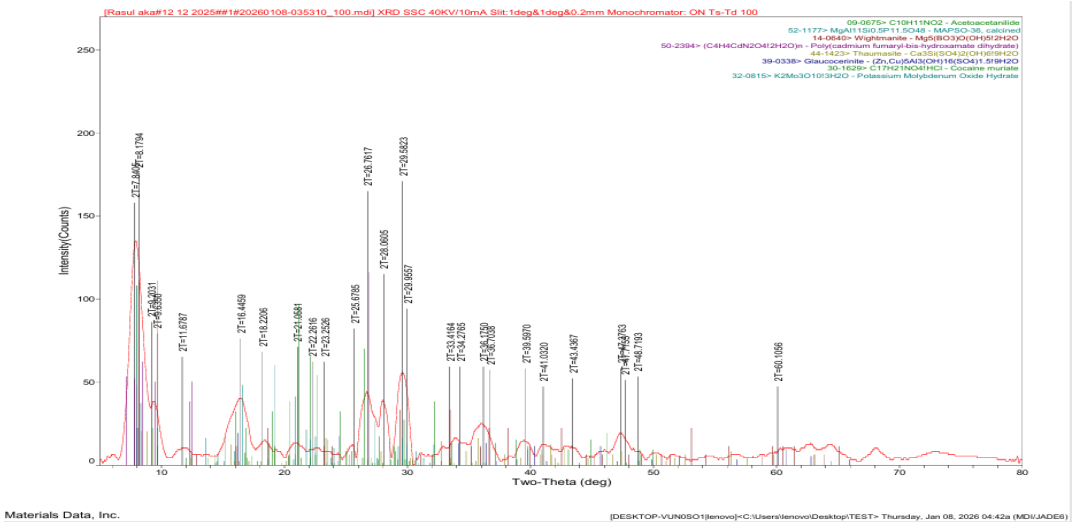
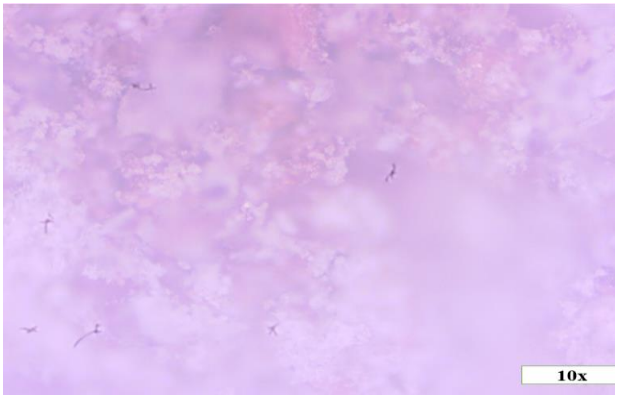


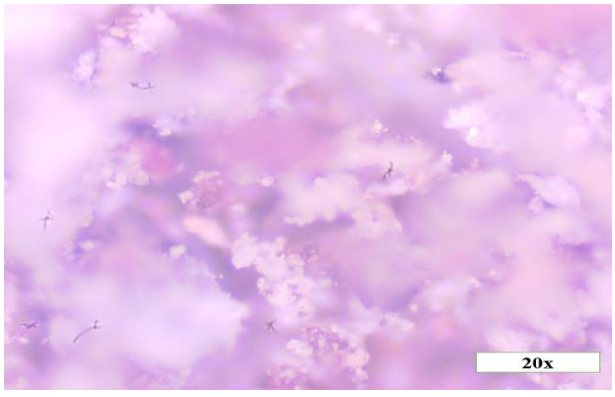
Fig. 4. X-ray phase analysis of a sample of expanded clay concrete with additives

By comparing the diffractogram results with the PDF (ICDD) database, the forsterite (Mg2SiO4) and magnesite (MgCO3) phases characteristic of the peroxynite mineral were determined in the sample. These phases indicate the preservation of magnesium and silicon compounds in the peroxynite and the formation of a stable crystalline structure in the concrete matrix. The presence of the forsterite phase is an important factor ensuring the material's resistance to high heat and chemical influences [5].

According to the results of microscopic analysis at 10x and 20x magnification of expanded clay concrete samples prepared without chemical additives with the addition of the mineral peroxynite, it was established that the internal structure of the concrete is relatively homogeneous and stable. Sufficiently dense contact zones have formed between the cement matrix, expanded clay aggregate grains, and the mineral particles of peroxynite, and a uniform distribution of pores is observed throughout the volume (Fig. 5).

The clear manifestation of the boundaries of the matrix and filler with increasing magnification confirms the positive role of the peroxynite mineral in structure formation. The properties of this microstructure contribute to the improvement of lightness, structural stability, and thermal and technical indicators of expanded clay concrete [6].





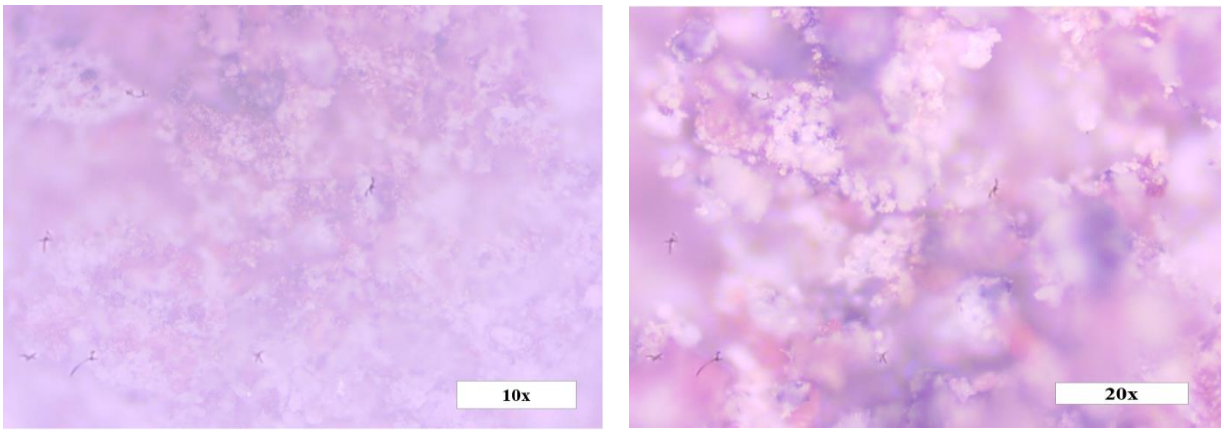


Fig. 5. 10x and 20x magnified microscopic structure of a sample of expanded clay concrete without additives and with the addition of 0.6% chemical additives

Microscopic analysis with 10x and 20x magnification of expanded clay concrete samples with the addition of the mineral peroxynite and the chemical additive Sika® 43.36 in an amount of 0.6% showed a significant compaction of the internal structure of the concrete. It was established that strong and continuous contact zones have formed between the cement matrix, expanded clay granules, and mineral particles of peroxynite (Fig. 5).

The more pronounced manifestation of the boundaries of the binding phase and filler with increasing magnification confirms the dispersing and structure-forming effect of the chemical additive. The predominance of small and closed pores in the microstructure, as well as the reduction of large voids, contributes to the improvement of structural stability, strength, and thermal and technical indicators of concrete [7].

4. Conclusion

The results of electron microscopic and X-ray phase analyses confirmed that the mineral peroxynite and the complex chemical additive Sika® 43.36 have a significant influence on the microstructure and phase composition of expanded clay concrete. Although relatively stable contact zones were formed between the cement matrix and the filler in the sample without the chemical additive, the presence of open and large pores in the structure was observed.

In the samples of expanded clay concrete with the addition of the mineral peroxynite and the additive Sika® 43.36 in an amount of 0.6%, significant compaction occurred at the microstructural level, and strong and continuous filling-bonding interface zones were formed between the cement matrix and expanded clay granules. Electron microscopic images showed a predominance of small and closed pores in the microstructure and a decrease in large voids, which creates favorable conditions for improving the structural stability and thermal and technical properties of concrete.

The results of X-ray phase analysis showed an increase in the proportion of cement hydration products, in particular calcium silicate hydrates (C-S-H), and a decrease in the amount of free calcium hydroxide (Ca (OH) 2) in the composition of modified expanded clay concrete. This circumstance is explained by the activation of secondary hydration processes under the influence of the puzolic activity and chemical additives of the peroxynite mineral. The detection of forsterite (Mg_2SiO_4) and magnesite ($MgCO_3$) phases on diffractograms is an important factor ensuring high thermal and chemical stability of expanded clay concrete.

The combined formation of crystalline and amorphous phases determines the composite nature of expanded clay concrete, ensuring its mechanical strength, resistance to heat and aggressive environments, and the possibility of stable operation under long-term operating conditions. The obtained results scientifically substantiate the mechanism of the complex influence of mineral and chemical additives on the formation of the structure of expanded clay concrete and confirm their effectiveness.

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